HETA 99–0085–2736
U.S. Precision Lens, Incorporated
Cincinnati, Ohio

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PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, technical and consultative assistance to Federal, State, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Nancy Clark Burton, of the Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Analytical support was provided by Ardith Grote, Analytical Research and Development Branch, Division of Physical Sciences and Engineering. Desktop publishing was performed by Nichole Herbert. Review and preparation for printing was performed by Penny Arthur.

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Health Hazard Evaluation Report 99–0085–2736
U.S. Precision Lens, Incorporated
Cincinnati, Ohio
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SUMMARY

In January 1999, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation (HHE) request from the management at U.S. Precision Lens, Inc. (USPL) in Cincinnati, Ohio. The HHE request asked for assistance in evaluating workers' exposures to an acrylic polymer (Shinkolite–P UT–100), specifically the component n–cyclohexylmaleimide (n–CHMI). The polymer is used in the production of lenses for large screen projection television sets. NIOSH conducted an HHE for USPL in 1998 that looked at employees' exposures to the components of UT–100 and developed a screening method for n–CHMI. Methyl methacrylate (MMA), n–CHMI, styrene, and alpha–methyl styrene were determined to be the main components in the bulk polymer material. It was recommended in the final report that the company conduct environmental monitoring during maintenance activities and use portable local exhaust ventilation during maintenance and purging activities. The company was unable to locate an analytical laboratory to analyze the environmental samples and requested assistance from NIOSH in monitoring maintenance activities. They had also purchased a portable local exhaust hood to use in the molding room. Environmental monitoring was conducted on February 2, 1999.

Three personal breathing zone (PBZ) and four area air samples were collected on thermal desorption tubes and analyzed for n–CHMI and other volatile organic compounds (VOCs). The three PBZ concentrations for n–CHMI ranged from trace levels to 2.26 micrograms per cubic meter ($\mu g/m^3$). The four area air sample concentrations ranged from non–detectable to 104 $\mu g/m^3$. The sample collected directly over the screw heating element during the maintenance activities showed the highest level of n–CHMI. For the first HHE, area air sample concentrations for n–CHMI ranged from non–detectable to 341 $\mu g/m^3$ (purging operation) and the PBZ concentrations for n–CHMI ranged from non–detectable to 3.82 $\mu g/m^3$.

Other VOCs detected in low concentrations from these samples include MMA, styrene, trichloroethylene, alpha–methyl styrene, acetone, isopropanol, propylene glycol, azobis (isobutyronitrile), methyl ethyl ketone, methanol, methyl isobutyrate, and possibly dimethyl or ethyl isomers of n–CHMI. Some of these could be created from the heating of the UT–100.

In general, the sample concentrations for n–CHMI determined during this survey were lower than those measured during the previous HHE. Based on the limited environmental monitoring data, the portable local exhaust ventilation hood appears to be effective in reducing the level of n–CHMI entering the air during purging and maintenance activities.

Keywords: SIC Code 3089 (Plastics Products, Not Elsewhere Classified), television lens, injection molding, (Shinkolite–P UT–100), n–cyclohexylmaleimide, n–CHMI, styrene, methyl methacrylate.

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INTRODUCTION

In January 1999, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation (HHE) request from the management at U.S. Precision Lens, Inc. (USPL) in Cincinnati, Ohio. The HHE request asked for assistance in evaluating maintenance workers' exposures to an acrylic polymer (Shinkolite–P UT–100), specifically the component, n–cyclohexylmaleimide (n–CHMI). NIOSH had conducted an HHE for USPL in 1998 to look at employees' exposures to the components of UT–100, and had developed a new analytical screening method for n–CHMI.[1] It was recommended in the final report that the company conduct environmental monitoring during maintenance activities and use portable local exhaust ventilation during maintenance and purging activities. The company was unable to locate a commercial analytical laboratory to use the new method for n–CHMI. They had also purchased a portable local exhaust hood which they wanted evaluated as part of the maintenance process. In response to this HHE request, a site visit was conducted on February 2, 1999, to collect environmental air samples toward evaluation of the company's engineering controls.

BACKGROUND

U.S. Precision Lens, Inc. manufactures lenses for large screen projection television sets as well as other lens products. The acrylic polymer, Shinkolite–P UT–100, is a combination of methyl methacrylate (MMA), alpha–methyl styrene, styrene, and n–CHMI, the latter making the product more heat resistant. The lens production process is continuous. Production employees work on teams in 12–hour shifts and rotate through a two–week schedule (every other weekend off). Engineers may also work in the production area if their project uses UT–100.

The robotic plastic injection molding machines are enclosed except at the top. The acrylic polymer pellets are dried, preheated, and vacuum–fed into the hopper of the molding machine. Mechanical rotation and friction are used to melt the pellets. If the process temperature exceeds 500°F, emergency alarms sound, and the molding machine shuts–off automatically. The liquid material is injected into the metal mold and allowed to solidify. The parts are cool at this point and the operators visually inspect them. The injection molding machine barrels are heated and purged (old material is removed) before being restarted.

The robotic injection molding machines are housed in the video optics molding (VOM2) area. The VOM2 area is a large open space which is serviced by a single ventilation system. The ventilation system is set–up to provide 14 air changes per hour (ACH). The return air is filtered through a high efficiency particulate air (HEPA) filter with 17% outside make–up air. The ventilation system has an emergency setting which purges all of the air in VOM2. A ventilation assessment was completed by a private consultant in March 1998, and showed that contaminants moved away from the employees toward the wall air returns located above the floor. Supply air is provided through ceiling diffusers, and four large exhaust grilles are located in the back wall.

Maintenance is performed on the robotic injection molding machines once or twice a week depending upon production rate and quality control. This process consists of purging the machine, removing the screw, cleaning out the interior of the heating area while still hot, sand–blasting the screw, and reassembling the screw heating mechanisms. The employees wore heat–resistant gloves. Preventive maintenance is also performed on the robotic injection molding machines once a month. In response to a recommendation made in the previous HHE, a portable local exhaust hood was purchased and used during purging and maintenance activities. The device has a hood connected to flexible duct work which can be positioned close to the purging area. It has two series of filters – one set of filters which is 98% efficient for the collection of metal fumes and the other set of charcoal filters which is used to collect volatile emissions.

Data from the 1998 HHE showed that MMA, n–CHMI, styrene and alpha–methyl styrene were the main chemicals given off when the bulk polymer material was heated to the process temperature using a head space analysis.[1] Since the bulk polymer material is added to the injection molding machines automatically and there appears to be very limited worker exposure to airborne dust, we decided to monitor for n–CHMI vapor only. Two area air samples collected during the purge process next to the large mound of extruded material as it cooled indicated air concentrations of 41 and 341 micrograms per cubic meter (µg/m^3) of n–CHMI. Other area air sample concentrations, which were collected around other molding machines in the same room, ranged from non–detectable to 2.9 µg/m^3. For the press associates, the personal breathing zone (PBZ) n–CHMI concentrations ranged from non–detectable to 3.8 µg/m^3 as time–weighted averages. For the VOC air sampling, the major compounds detected were isopropanol, trichloroethylene, and MMA. Other compounds found included n–CHMI, dimethyl ether, styrene, alpha–methyl styrene, limonene, aliphatic acid esters, nicotine, chlorofluoro hydrocarbons, xylene, butyl cellosolve, methyl ethyl ketone, and some fragrance compounds. Concentrations of styrene and MMA collected as full–shift quantitative air samples were non–detectable.

METHODS

n–Cyclohexylmaleimide (n–CHMI)

Three PBZ and four area air samples were collected on thermal desorption tubes containing three beds of sorbent material. Prior to analysis, the samples were dry purged with helium to remove water. The samples were analyzed for n–CHMI using a Perkin–Elmer automatic thermal desorption (TD) system interfaced directly to a gas chromatograph (GC) and a mass selective detector (MSD). Stock solutions in acetone, containing known amounts of n–CHMI, were used to prepare standards to estimate concentrations. The spike samples were prepared by inserting blank TD tubes into a GC injector and aliquots of the standard stock solutions were injected and analyzed as described above. For quantitation of the n–CHMI, a single ion characteristic of the compound was used to improve the sensitivity of the technique and to reduce interference from other compounds. The analytical limit of detection (LOD) was 0.002 micrograms (µg), which is equivalent to a minimum detectable concentration (MDC) of 0.32 µg/m^3 assuming a sample volume of 6.25 liters. The limit of quantitation (LOQ) was 0.0067 µg, which is equivalent to a minimum quantifiable concentration (MQC) of 1.07 µg/m^3, assuming a sample volume of 6.25 liters. Since the sampling method and analytical techniques used in these analyses have not been fully evaluated, the results should be considered estimates. Other volatile organic compounds (VOCs) were also identified, but not quantified from the TD–GC–MSD analyses.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre–existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs),[2] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[3] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration

(OSHA) Permissible Exposure Limits (PELs).[4] Employers are encouraged to follow the more protective criterion. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard.

A time–weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8– to 10–hour workday. Some substances have recommended short–term exposure limits (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short–term.

n–Cyclohexylmaleimide (n–CHMI)

An extensive literature search failed to locate published studies concerning the toxicity or health effects associated with occupational exposure to n–CHMI. The material safety data sheet (MSDS) for this product lists it as a severe eye and respiratory irritant. Mitsubishi Rayon America, the manufacturer of the UT–100 material, provided information to USPL on two acute inhalation studies using rats exposed to n–CHMI. No data was provided on chronic effects. The first study used 30 rats (five control animals and two sets of exposed animals [five in each group] for each sex). Experimental Group 1 (five males and five females) was exposed to 13 milligrams per cubic meter (mg/m^3) of n–CHMI aerosol for 4 hours and Experimental Group 2 (five males and five females) was exposed to 15 mg/m^3 n–CHMI vapor for 4 hours. In Experimental Group 1, 8 of the 10 rats (3 males and 5 females) died at that exposure level. They exhibited symptoms of exposure to an irritant aerosol including partial closure of the eyes, wetness around the nose and mouth, abnormal respiration, and death. None of the animals in Experimental Group 2 died. They showed symptoms of partial closure of the eyes and wetness around the nose and mouth, and had no residual symptoms by the fourth day of follow–up.

In the other study, a series of animals was exposed to n–CHMI vapor concentrations of 550 $\mu g/m^3$, 250 $\mu g/m^3$, and 50 $\mu g/m^3$ for 6 hours per day for 28 days. Rats at the highest exposure level showed a decrease in weight, a decrease in food intake, and developed upper trachea irritation. Rats exposed at 250 $\mu g/m^3$ showed some decrease in weight, a decrease in food intake in males, and developed upper trachea irritation. Rats exposed at 50 $\mu g/m^3$ developed slight irritation of the upper trachea.

Mitsubishi Rayon America has established a suggested exposure limit of 0.6 $\mu g/m^3$ as an 8–hour TWA for n–CHMI. The suggested exposure limit is based on a risk assessment formula that used 50 $\mu g/m^3$ as the exposure factor from the inhalation study mentioned above and conversion factors to account for the animal toxicity data. A large safety factor of 500 was used in the risk assessment to obtain the suggested exposure limit. The MSDS also recommends that respiratory protection (organic vapor cartridges), chemical resistant gloves, and local exhaust ventilation be used at all times to prevent exposure to n–CHMI.

RESULTS

n–Cyclohexylmaleimide (n–CHMI)

The air monitoring data for n–CHMI are presented in Table 1. For the maintenance staff members and press associate whose exposures were monitored, the PBZ concentrations ranged from trace levels to 2.26 $\mu g/m^3$. The four area sample concentrations ranged from non–detectable to 104 $\mu g/m^3$. The sample collected directly over the screw heating element during the maintenance activities of removing the screw and cleaning the barrel showed the highest concentration of n–CHMI.

Qualitative Analysis of Volatile Organic Compounds (VOCs)

Copies of the chromatograms for the thermal tube desorption analyses are included in Appendix A, along with a list of the substances identified in the chromatograms. Besides n–CHMI, other compounds detected at low concentrations include methyl methacrylate, styrene, trichloroethylene, alpha–methyl styrene, acetone, isopropanol, propylene glycol, azobis(isobutyronitrile), methyl ethyl ketone, methanol, methyl isobutyrate, and possibly dimethyl or ethyl isomers of n–CHMI. Some of these could be created from the heating of the UT–100 and others could be from cleaning products used in the work area.

DISCUSSION AND CONCLUSIONS

From the previous survey, it was anticipated that the highest exposures to n–CHMI would be during the purge process and while preforming maintenance activities. These are short–term activities. The PBZ sample concentrations for n–CHMI collected on the two individuals conducting the maintenance activities were trace levels and 2.26 µg/m^3. The area air sample concentration that was collected directly over the screw heating element during the maintenance activities was 104 µg/m^3. The area air samples for n–CHMI that were collected around and on the portable local exhaust ventilation hood ranged from non–detectable to 1.3 µg/m^3. For the first HHE, area air sample concentrations for n–CHMI ranged from non–detectable to 341 µg/m^3. The PBZ concentrations for n–CHMI ranged from non–detectable to 3.82 µg/m^3.

The air sample concentrations were not corrected for an eight–hour exposure since this monitoring was conducted to evaluate exposure to a specific maintenance activity. The environmental monitoring results collected during this survey showed lower exposures than the data collected during the previous HHE. Based on the limited environmental monitoring data collected on this follow–up evaluation, the portable local exhaust ventilation hood appears to be effective in reducing the level of n–CHMI entering the air during purging and maintenance activities.

RECOMMENDATIONS

1. The company should continue to encourage the use of the portable local exhaust ventilation equipment during the purging and maintenance activities and continue to maintain the equipment. The employees should be updated when additional health information concerning UT 100 is received.

2. Employees should be encouraged to report any health symptoms that they consider related to exposure to the UT 100 product to management.

REFERENCES

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4. Code of Federal Regulations [1997]. 29 CFR 1910.1000. Washington, DC: U.S. Government Printing Office, Federal Register.

Table 1
N–Cyclohexylmaleimide Air Sampling Results
Maintenance Process
Cincinnati, Ohio
HETA 99–0085

Sample Location	Sampling Time	Sample Volume (Liters)	n–Cyclohexyl–maleimide Concentration ($\mu g/m^3$)*
Personal			
Maintenance – UT100 #31	9:09 a.m. – 10:36 a.m.	4.4	Trace**
Purge Process/ Maintenance – UT100 #31	8:49 a.m. – 10:35 a.m.	5.3	2.26
UT100 #32 – Press Associate	8:35 a.m. – 10:40 a.m.	6.3	Trace
Area			
Top of Press UT100 #31 – Purge Area	8:51 a.m. – 10:37 a.m.	5.3	104
Back Corner of Room Near Press UT100 #31	8:40 a.m. – 10:40 a.m.	6.0	1.30
Screw Heating Element Area –Press UT100 #32	8:38 a.m. – 10:39 a.m.	6.0	Trace
Top of Filter Hoods	8:50 a.m. – 10:38 a.m.	5.4	ND^
Minimum Detectable Concentration (MDC)		6.3	0.32
Minimum Quantifiable Concentration (MQC)		6.3	1.07

* = µg/m3 (micrograms per cubic meter)
** = Trace – Concentration between MDC and MQC
^ = ND – Not detected at MDC

National Institute for Occupational Safety and Health (NIOSH) Study of UT100 Press Maintenance

In February 1999, a NIOSH representative conducted a health hazard evaluation (HHE) at the U.S. Precision Lens facility. Another HHE had been completed at this facility in 1998. We looked at exposures to UT 100 material in the molding room. This was a follow–visit to measure exposures during maintenance work on the presses.

What NIOSH Did

Collected air samples for UT 100 chemicals during purging and maintenance processes

Looked at new movable ventilation equipment

What NIOSH Found

Press associates and maintenance workers are exposed to low levels of chemicals from the molding process

Movable ventilation equipment lowers the level of chemicals in the air

What U.S. Precision Lens Managers Can Do

Continue to maintain ventilation equipment

Continue to update employees on additional health information about UT 100

What U.S. Precision Lens Employees Can Do

Continue to use movable ventilation equipment during purging and maintenance processes

Report any health problems that could be related to working with UT 100 to management

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

What To Do For More Information:
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1–513–841–4252 and ask for HETA Report # 99–0085–2736

National Institute for Occupational Safety and Health NIOSH

Appendix A
Volatile Organic Chemicals Chromatograms

For Information on Other
Occupational Safety and Health Concerns

Call NIOSH at:
1–800–35–NIOSH (356–4676)
or visit the NIOSH Homepage at:
http://www.cdc.gov/niosh/homepage.html